216/59, 79, 80

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WHAT IS CLAIMED IS:

1. A plasma processing method comprising the steps of:

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placing a substrate inside a reaction chamber of a plasma processing system, a silicon dioxide film having been formed on the surface of the substrate;

introducing a fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber; and 5,707,486 5,338,399

creating a plasma from the fluorocarbon gas and etching the $\boxed{\text{silicon dioxide film}}$ ~~with the~~ plasma,

wherein a residence time τ of the fluorocarbon gas in the reaction chamber is controlled at a value greater than 0.1 sec and equal to or less than 1 sec, the residence time τ being given by $P \times V / Q$, where P is a pressure (unit: Pa) of the fluorocarbon gas, V is a volume (unit: L) of the reaction chamber and Q is a flow rate (unit: Pa·L/sec) of the fluorocarbon gas. 5,244,730

2. The plasma processing method of Claim 1, wherein the fluorocarbon gas is a gas containing at least one of C_4F_8, C_4F_6, C_3F_8, C_5F_8 and C_6F_6 gases. 112 Objection

112 improper Markush group.

0.5

0.375 1

3. The plasma processing method of Claim 1, wherein the residence time τ is controlled by a mass flow controller provided for the plasma processing system and/or a valve and

a pump provided for the plasma processing system.

4. A plasma processing method comprising the steps of:

placing a substrate inside a reaction chamber of a plasma processing system, a silicon dioxide film having been formed on the surface of the substrate;

introducing a fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber; and

creating a plasma from the fluorocarbon gas and etching the silicon dioxide film with the plasma,

wherein $P \times W_0 / Q$ is controlled at a value greater than 0.8×10^4 sec·W/m^3 and equal to or less than 8×10^4 sec·W/m^3, $P \times W_0 / Q$ being a product of a residence time τ of the fluorocarbon gas in the reaction chamber and a power density Pi of power applied to create the plasma, the residence time τ being given by $P \times V / Q$, where P is a pressure (unit: Pa) of the fluorocarbon gas, V is a volume (unit: L) of the reaction chamber and Q is a flow rate (unit: Pa·L/sec) of the fluorocarbon gas, the power density Pi being given by W_0/V, where W_0 is a magnitude (unit: W) of the power and V is the volume (unit: L) of the reaction chamber.

P
W_0
Q

ER

5. The plasma processing method of Claim 4, wherein the fluorocarbon gas is a gas containing at least one of C_4F_8, C_4F_6,

C_3F_8, C_5F_8 and C_6F_6 gases.

6. The plasma processing method of Claim 4, wherein the residence time τ is controlled by a mass flow controller provided for the plasma processing system and/or a valve and a pump provided for the plasma processing system.

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11 7. A plasma processing method comprising the steps of:

placing a substrate inside a reaction chamber of a plasma processing system;

introducing a fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber; and 427/9

creating a plasma from the fluorocarbon gas and depositing an organic film on the substrate using the plasma,

wherein a residence time τ of the fluorocarbon gas is controlled at 0.1 sec or less, the residence time τ being given by $P \times V / Q$, where P is a pressure (unit: Pa) of the fluorocarbon gas, V is a volume (unit: L) of the reaction chamber and Q is a flow rate (unit: Pa·L/sec) of the fluorocarbon gas.

8. The plasma processing method of Claim 7, wherein the fluorocarbon gas is a gas containing at least one of C_4F_8, C_4F_6, C_3F_8, C_5F_8 and C_6F_6 gases.

9. The plasma processing method of Claim 7, wherein the residence time τ is controlled by a mass flow controller provided for the plasma processing system and/or a valve and a pump provided for the plasma processing system.

10. A plasma processing method comprising the steps of:

placing a substrate inside a reaction chamber of a plasma processing system;

introducing a fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber; and

creating a plasma from the fluorocarbon gas and depositing an organic film on the substrate using the plasma,

wherein $P \times W_0 / Q$ is controlled at 0.8×10^4 sec $\cdot$ W/m^3 or less, $P \times W_0 / Q$ being a product of a residence time τ of the fluorocarbon gas and a power density Pi of power applied to create the plasma, the residence time τ being given by $P \times V / Q$, where P is a pressure (unit: Pa) of the fluorocarbon gas, V is a volume (unit: L) of the reaction chamber and Q is a flow rate (unit: Pa $\cdot$ L/sec) of the fluorocarbon gas, the power density Pi being given by W_0/V, where W_0 is a magnitude (unit: W) of the power and V is the volume (unit: L) of the reaction chamber.

11. The plasma processing method of Claim 10, wherein

the fluorocarbon gas is a gas containing at least one of C_4F_8, C_4F_6, C_3F_8, C_5F_8 and C_6F_6 gases.

12. The plasma processing method of Claim 10, wherein the residence time τ is controlled by a mass flow controller provided for the plasma processing system and/or a valve and a pump provided for the plasma processing system.

13. A plasma processing method comprising the steps of:

placing a substrate inside a reaction chamber of a plasma processing system, a silicon dioxide film having been formed on the surface of the substrate;

introducing a first fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber;

creating a first plasma from the first fluorocarbon gas and etching the silicon dioxide film with the first plasma;

introducing a second fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber; and

creating a second plasma from the second fluorocarbon gas and depositing an organic film on the etched silicon dioxide film using the second plasma,

wherein a first residence time τ_1 of the first fluorocarbon gas in the reaction chamber is controlled at a value

greater than 0.1 sec and equal to or less than 1 sec, the first residence time τ_1 being given by $P_1 \times V / Q_1$, where P_1 is a pressure (unit: Pa) of the first fluorocarbon gas, V is a volume (unit: L) of the reaction chamber and Q_1 is a flow rate (unit: Pa·L/sec) of the first fluorocarbon gas, and

wherein a second residence time τ_2 of the second fluorocarbon gas in the reaction chamber is controlled at 0.1 sec or less, the second residence time τ_2 being given by $P_2 \times V / Q_2$, where P_2 is a pressure (unit: Pa) of the second fluorocarbon gas, V is the volume (unit: L) of the reaction chamber and Q_2 is a flow rate (unit: Pa·L/sec) of the second fluorocarbon gas.

14. The plasma processing method of Claim 13, wherein the first fluorocarbon gas is a gas containing at least one of C_4F_8, C_4F_6, C_3F_8, C_5F_8 and C_6F_6 gases, and

wherein the second fluorocarbon gas is a gas containing at least one of C_4F_8, C_3F_8, C_5F_8 and C_6F_6 gases.

15. The plasma processing method of Claim 13, wherein each of the first and second residence times τ_1 and τ_2 is controlled by a mass flow controller provided for the plasma processing system and/or a valve and a pump provided for the plasma processing system.

16. A plasma processing method comprising the steps of:

placing a substrate inside a reaction chamber of a plasma processing system, a silicon dioxide film having been formed on the surface of the substrate;

introducing a first fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber;

creating a first plasma from the first fluorocarbon gas and etching the silicon dioxide film with the first plasma;

introducing a second fluorocarbon gas, which contains carbon and fluorine and in which a ratio of carbon to fluorine is 0.5 or more, into the reaction chamber; and

creating a second plasma from the second fluorocarbon gas and depositing an organic film on the etched silicon dioxide film using the second plasma,

wherein $P_1 \times W_1 / Q_1$ is controlled at a value greater than 0.8×10^4 sec · W/m^3 and equal to or less than 8×10^4 sec · W/m^3, $P_1 \times W_1 / Q_1$ being a first product of a first residence time τ_1 of the first fluorocarbon gas in the reaction chamber and a power density Pi_1 of first power applied to create the first plasma, the first residence time τ_1 being given by $P_1 \times V / Q_1$, where P_1 is a pressure (unit: Pa) of the first fluorocarbon gas, V is a volume (unit: L) of the reaction chamber and Q_1 is a flow rate (unit: Pa · L/sec) of the first fluorocarbon gas, the power density Pi_1 being given by W_1/V, where W_1 is a

magnitude (unit: W) of the first power and V is the volume (unit: L) of the reaction chamber, and

wherein $P_2 \times W_2 / Q_2$ is controlled at 0.8×10^4 sec $\cdot$ W/m^3 or less, $P_2 \times W_2 / Q_2$ being a second product of a second residence time τ_2 of the second fluorocarbon gas in the reaction chamber and a power density Pi_2 of second power applied to create the second plasma, the second residence time τ_2 being given by $P_2 \times V / Q_2$, where P_2 is a pressure (unit: Pa) of the second fluorocarbon gas, V is the volume (unit: L) of the reaction chamber and Q_2 is a flow rate (unit: Pa $\cdot$ L/sec) of the second fluorocarbon gas, the power density Pi_2 being given by W_2/V, where W_2 is a magnitude (unit: W) of the second power and V is the volume (unit: L) of the reaction chamber.

17. The plasma processing method of Claim 16, wherein the first fluorocarbon gas is a gas containing at least one of C_4F_8, C_4F_6, C_3F_8, C_5F_8 and C_6F_6 gases, and

wherein the second fluorocarbon gas is a gas containing at least one of C_4F_8, C_3F_8, C_5F_8 and C_6F_6 gases.

18. The plasma processing method of Claim 16, wherein each of the first and second residence times τ_1 and τ_2 is controlled by a mass flow controller provided for the plasma processing system and/or a valve and a pump provided for the plasma processing system.